



Exploring the relation between the structure strategy and source attention in single expository text comprehension: a cross-sectional study in secondary education

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Abstract

Organisational signals and sources can be considered metatextual cues that guide the processing of the discourse. Organisational signals encourage readers to use the structure strategy, while source information reveals the epistemic and formal properties of texts. This study addressed three gaps in prior research about these topics: (1) whether organisational signals were useful for 12–14/14–16-year-old students reading causal and sequential texts, (2) the role of sources in single-text understanding, and (3) the relationship between sensitivity to organisational signals (rhetorical competence) and attention to sources. Participants read causal and sequential texts with or without these metatextual cues and wrote a summary. Summary quality was considered an indicator of understanding and using the structure strategy. The number of sources translated into the summaries was considered an indicator of source attention. The results indicated that (1) organisational signals had an effect on summary quality in both age groups and texts; (2) sources did not affect summary quality, but when participants read signalled texts, the number of sources mentioned made a unique contribution to summary quality beyond decoding, general reading comprehension and rhetorical competence; and (3) the number of sources mentioned correlated with rhetorical competence among participants who read the signalled texts. These results suggest that 12–16-year-old students need the aid of organisational signals to launch the structure strategy with causal and sequential texts and that sources may be more useful in combination with organisational signals, but only for students with some level of rhetorical competence, illustrating the intricacy of literacy development.

Keywords Literacy development · Metatextual cues · Rhetorical competence · Source attention · Structure strategy

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Introduction

Beyond their propositional content, texts include nonpropositional elements that refer to the text itself or track the author's communicative intentions (Lemarié et al., 2008). These elements can be conceptualized as metatextual cues because they constitute a metatext or handbook that guides competent readers in the processing of the discourse (Britton, 1994; Gernsbacher, 1996; Givón, 1992; Goldman & Rakestraw, 2000; Hyland, 2010; Lemarié et al., 2008).

One class of metatextual cues of particular importance to expository text comprehension are the written signals that make explicit the organisation chosen by the writer, e.g., organisational signals (such as “a first characteristic/step/cause/solution is...”), macrostatements, headings, etc. These signals create an overall framework for the text, indicate its main ideas, and aid the reader in using the structure strategy, that is, to recognize and use the structure of a text to select and organise the important information (Meyer et al., 1980; Sanders & Noordman, 2000). The structure strategy and its promotion by means of written signals have been important topics of research (see, for instance, the introduction from Williams, 2018 to one special issue about the topic). One useful conclusion provided by this research is that the effectiveness of written signals depends on a reader's sensitivity to them (Brooks et al., 1983; Goldman & Rakestraw, 2000; Lemarié et al., 2008) or the reader's rhetorical competence (Sánchez & García, 2009; Sánchez et al., 2017, 2020). Nevertheless, there are still some gaps regarding which readers need written signals to launch the structure strategy and in which type of text they need the signals.

On the other hand, a broad notion of metatextual cues could also include some text features that used to be encompassed under the concept of “source”: author, publication date, document type, etc. (e.g., Britt & Aglinskas, 2002; Wineburg, 1991). Sources provide information about the epistemic (e.g., reliability) and formal properties of the documents (Barzilai et al., 2015). That is, source information goes beyond the propositional content of the texts, as any other metatextual cue. In fact, Goldman and Scardamalia (2013) refer to the ability to attend and represent a source's information (sourcing) as the process of identifying and representing metadata, and poor sourcing can be explained as the tendency of some readers to focus solely on text content (Bråten et al., 2019). The function of source information and sourcing have also been other important research topics in the last few years (see, for instance, the review from Bråten et al., 2018) because many reading tasks require sourcing (Barzilai et al., 2018; Goldman et al., 2013; OECD, 2019). It has been argued that one function of sources (in addition to validating/selecting reliable information and integrating information from different sources) is to assist with the understanding and interpretation of text ideas (Brante & Strømsø, 2018; Rouet, 2006; Strømsø et al., 2010). However, most studies about sources have been conducted with multiple texts or with single texts with embedded sources (e.g., Bråten et al., 2016, 2018), while single texts with information from only one source may be a good scenario to test the utility of sources for reading comprehension (not for validating/selecting reliable information or integrating information from different sources).

In sum, there are some reasons to continue the study of these two types of metatextual cues (written signals and sources) and their related skills (the structure strategy and sourcing). Furthermore, previous research has examined these features of texts and readers separately, while the notion of metatextual cues provides a frame for exploring the aspects shared by them to understand the intricacy of literacy development.

Based on these arguments, we conducted a study with a sample of Spanish secondary education students (seventh to tenth grade: 12–16 years old) who were asked to read two texts (a sequential text and a causal text). There were three main aims of this study. The first aim was to examine whether these students were able to use the structure strategy spontaneously and successfully or whether they took advantage of the aid of organisational signals inserted in the texts. The second aim was to assess the impact of source manipulation and one indicator of sourcing (source attention) on reading comprehension. The third aim was to analyse whether the students who were more sensitive to the organisational signals (that is, the students with a higher level of rhetorical competence) also paid more attention to the mention of an expert source in the texts: if so, this would be an indicator of a broad ability to distinguish nonpropositional text elements or metatextual cues.

Readers' ability to use the structure strategy throughout secondary education

Expository texts have an unfamiliar and cognitively complex structure (Al Otaiba et al., 2018) as description, sequence, comparison, cause-effect, or problem–solution (Meyer, 1985). Thus, an important strategy to understand and learn from this type of text is recognizing their specific structure to select and organise their main ideas in a coherent mental representation (Hebert et al., 2016; Meyer et al., 1980; Williams, 2018). This strategy is known as the “structure strategy” (Meyer et al., 1980).

Highly competent readers launch the structure strategy to mentally reorganise even poorly written texts, which is the goal of text structure instruction (Williams, 2018). However, every strategy may also be activated by objective cues informing the reader in how and when to use it (Graesser, 2007). In the case of the structure strategy, such objective cues may be written rhetorical devices or signals that make explicit the organisation chosen by the writer (e.g., organisational signals such as “a first characteristic/step/cause/solution is...”; macrostatements; headings). Thus, if a reader needs the presence of written signals to better use the structure strategy, it means that this reader does not fully master the strategy; however, such a reader may be considered more skilful than another reader who needs more powerful cues to use the same strategy (e.g., a teacher oral request: Sánchez et al., 2020) or who does not use it regardless of the kind of cues provided.

Consequently, one way to determine the level of mastery of the structure strategy is to analyse whether readers are equally good at selecting and organising the ideas of a text with written signals and without them: thus, whether there is a signalling effect (Meyer et al., 2018). There are few studies of this type among 12–16-year-old students.

McNamara et al. (1996) evaluated the text base representation of students aged 10–15 after reading two descriptive texts. One group of participants read the original texts, and the other group read a version in which the structure was explicitly signalled by topic headers and organisational signals. In Experiment 1, participants who read the text with signals recalled more main ideas, but this result was qualified in Experiment 2 by an interaction between text version and background knowledge: high-knowledge participants were able to construct a good text base representation with or without the help of the signals, while low-knowledge participants needed the version of the text in which the structure was explicitly signalled. These results suggest that low-knowledge participants did not master the structural strategy with descriptive texts. However, it is not possible to know whether high-knowledge participants detected the organisational structure of the text or if their prior knowledge was already organised in a manner similar to that of the text. Thus, to avoid this ambiguity, in the current study, we selected texts about unfamiliar topics for our participants.

In a classic study within this paradigm, Meyer et al. (1980) asked 14–15-year-old students divided into groups of good, average, and poor comprehenders to read signalled or nonsignalled versions of a text with a problem–solution structure and another with a comparison structure. The signalled version of the texts included organisational signals. In an immediate and delayed recall, the majority of good comprehenders used the same type of top-level structure for organizing their recalls as the author of both texts without showing a signalling effect. Nevertheless, among the rest of the students, a subgroup classified as underachievers (readers with adequate word knowledge and word attack skills but poorer reading comprehension) obtained better scores in the immediate recall condition with signals than under the condition without signals (there was a signalling effect) but only in the problem–solution text. The authors concluded that written signals in the problem–solution passage assisted the learning and immediate retrieval of students with deficient comprehension skills because they could not employ the structure strategy without assistance, while these students could not obtain a benefit from written signals from the comparison text because this text included few words of signalling.

Sánchez et al. (2017) had 11–13-year-old students read a cause-effect text under two conditions: with or without written signals (mainly organisational signals). After reading, students produced a summary. The results showed that readers of the text with signals selected and organised the ideas translated to the summary better than readers of the text without signals, meaning that these students did not fully master the structure strategy when facing a cause-effect text. However, an additional result of this study showed that the signalling effect was moderated by the capability of detecting, interpreting, and using written signals as processing instructions. This ability is called rhetorical competence (García et al., 2015, 2019; Sánchez & García, 2009; Sánchez et al., 2020). The moderator analysis of the study from Sánchez et al. (2017) showed that launching the structure strategy with the aid of written signals required a moderate or good level of rhetorical competence. Thus, in the current study, we assessed rhetorical competence to ensure that our participants were over this threshold. Otherwise, if there was no signalling effect, we would not be able to

identify the cause: a lack of rhetorical competence or a deficit in the structure strategy (Sánchez et al., 2020).

Finally, Loman and Mayer (1983) also studied the performance with signalled and nonsignalled cause-effect texts of two groups of 15–17-year-old students: good and poor readers. In the signalled conditions, the structure of the texts was made explicit by means of preview sentences stating the purpose of the text, summaries, headings to show which paragraph represented each cause/phase of the phenomenon explained, and logical connectives. Both good and poor readers who read the version of the text with signals were able to recall the conceptual information more effectively than those in the group who read a version of the text without signals. Consequently, these readers did not spontaneously launch the structure strategy with these cause-effect texts. Nevertheless, participants read along silently while they listened to the experimenter reading the passage aloud. This specific condition of reading prevents us from reaching a general conclusion about the use of the structure strategy with cause-effect texts at the end of secondary education because some experimental data suggest that, in this situation, the students must focus on their individual reading, making an effort not to listen to the person reading aloud (García-Rodicio et al., 2018). As this consumes cognitive resources, we do not know whether good readers at this age in a quiet situation could use the structure strategy without the assistance of written signals.

In sum, these studies show that the use of the structure strategy is still a challenge for secondary education students. When reading texts organised as description, comparison, or problem–solution, only good comprehenders and high-knowledge readers seem to master the structure strategy; the rest of the students may have some knowledge of the structure strategy, but they may be unable to use it fully without the help of written signals, which makes the organisation of the text explicit (McNamara et al., 1996; Meyer et al., 1980). With respect to the cause-effect structure, the data are less clear: students at the beginning of secondary education need the support of written signals (Sánchez et al., 2017), but we do not know whether more skilled or older readers are able to fully use the structure strategy without assistance when reading alone. Finally, it seems that there is a lack of studies conducted with texts organised as a sequence. Thus, the first objective of our study is to assess the use of the structure strategy with and without signals by 12–14 and 14–16-year-old students when reading a cause-effect and a sequential text to complete the description of how readers with different levels of competence interact with all the variety of text structures.

The role of sources and sourcing in text reading

Texts, as social entities written by someone for some purpose, also include many features beyond their propositional content and structure, which used to be encompassed under the concept of “source”: author, publication date, document type, etc. (e.g., Britt & Aglinskias, 2002; Wineburg, 1991). Attending to and representing such information while reading (sourcing) may have at least three benefits or functions.

First, sourcing is useful for *validating and selecting* reliable information because the source allows readers to understand the aim and context of a text to judge the quality and credibility of its information (Brante & Strømsø, 2018; Potocki et al., 2020). This function of sources is especially important in multiple-text task-oriented reading (Barzilai et al., 2018; Goldman et al., 2013; OECD, 2019).

Second, sourcing *aids in integrating* information from different sources (Britt & Rouet, 2012), realizing that, for instance, one source corroborates, supports, exemplifies, or disagrees with others. Again, this function of sources is important when reading multiple documents, especially, according to the D-ISC model (Braasch & Bråten, 2017), if those documents deliver conflicting claims (Anmarkrud et al., 2014; Anmarkrud et al., 2013; Barzilai & Ka'adan, 2017; Braasch & Bråten, 2017; Saux et al., 2021) but also when a single text offers information from different embedded sources, mainly—like in the case of multiple texts—if their messages are controversial (Braasch & Bråten, 2017; Saux et al., 2017). In these cases, conflicting information could not coexist in a coherent representation without paying attention to the sources.

Finally, sourcing may be relevant for *understanding* text ideas (Rouet, 2006) because the type of information encapsulated by sources may be useful for interpreting the text (Brante & Strømsø, 2018; Strømsø et al., 2010). For instance, source information may orient to the specific meaning of some words (e.g., dissonance does not mean the same for a musician and a psychologist), to the general interpretation of the message (e.g., one politician's declaration does not mean the same before or after the elections), and to the nature and typical features of the text (e.g., the readers who are reading a text written by a university professor may expect to find an expository text organised in a logical way, which in turn, may predispose them to employ the structure strategy). Thus, source information could facilitate the process of laying a foundation for the mental representation of the text, which is a highly demanding process occurring when a reader is first confronted with new information (Gernsbacher, 1990). Evidence supporting the role of sources on comprehension may be found in some studies with multiple texts where sourcing relates to the comprehension of the materials (Bråten et al., 2009; Goldman et al., 2012; Strømsø et al., 2010; Wiley et al., 2009). Nevertheless, the presence of a source and sourcing may also be related to the comprehension of single texts providing information from just one source. Moreover, in multiple-text tasks, if participants with high sourcing skills are better able to understand texts that correspond to more reliable sources, this may be the result of having read only those texts. For this reason, a single-text reading task may be a good approach to ascertain whether the incorporation of a reliable source and its subsequent identification and representation by readers influences comprehension.

On the other hand, prior research indicates that readers' spontaneous attention to and use of sources is generally low when they read both multiple texts or single texts with embedded sources, even among secondary school (Barzilai & Ka'adan, 2017; Britt & Aglinskas, 2002; Stahl et al., 1996; Wineburg, 1991) and university students (Bråten et al., 2016; Britt & Aglinskas, 2002; Stadler & Bromme, 2007). However, dealing with more than one source may be a very demanding task, and sourcing may be impoverished if there is semantic overlap among the ideas provided

by each source (Braasch et al., 2016). Thus, we explored sourcing asking participants to read single texts with only one embedded source as a way of reducing the amount of source information available and, therefore, the cognitive load of processing sources. In doing so, it is possible to analyse whether, under these conditions, readers' spontaneous attention to sources is higher than in prior research.

Regarding the relationship between the structure strategy and sourcing

Single text and multiple document comprehension are different yet correlated constructs (Mahlow et al., 2020). This means that they are based, to some extent, on some common underlying abilities (e.g., decoding words and language comprehension: Florit et al., 2020; Salmerón & García, 2011). There is also a study showing that written signals that make rhetorical relationships explicit in single texts are also useful when undergraduate students read multiple documents about a controversy (Stadtler et al., 2014). To advance in the study of the commonalities between single text and multiple document comprehension, we are interested in the relationship between the structure strategy and sourcing.

The structure strategy can be triggered by signals that make explicit the organisation of text ideas. These signals are cues or "potential processing instructions" that help readers understand a text (Givón, 1992; Lemarié et al., 2008). The source of a document can be understood as another kind of cue that provides information about the epistemic (e.g., its reliability) and formal properties of the documents (Barzilai et al., 2015). Consequently, both kinds of cues (signals and sources) are metatextual devices that clarify some aspects of the text without affecting its organisation or content (Hyland, 2010). Rhetorical competence, which has proven to be needed for the processing of signals (Sánchez et al., 2017), could therefore show some relationship with sourcing: students with higher rhetorical competence may also be more sensitive to sources.

An additional justification for a possible link between sourcing and rhetorical competence is that both skills are based on similar processes. Sourcing, in a broad sense, has been defined as attending to, representing, evaluating and using information related to the sources (Braasch & Bråten, 2017; Bråten, et al., 2018, 2019), while rhetorical competence involves three processes (Sánchez et al., 2020): the detection of the rhetorical device or signal (similar to attending to and representing), the interpretation of its meaning as a guide for processing the text (similar to evaluating), and the transformation of this suggestion into a reading objective (similar to using, e.g., "I am going to find the first cause of this phenomenon").

Given the above arguments, the third main objective of our study was to explore whether a measure of sourcing (sources attention) was related to the structure strategy through rhetorical competence. If so, new evidence of the link and continuity between single- and multiple-text reading skills could be obtained. A relationship in the expected direction would mean that an underlying ability for single text comprehension and multiple document comprehension is sensitivity to metatextual cues.

The present study

Research on the use of the structure strategy has shown that among secondary education students, readers with different levels of competence have different knowledge of the structure strategy (McNamara et al., 1996; Meyer et al., 1980). In addition, Spanish batteries for assessing reading skills still report differences in general reading comprehension within the different grades of secondary education (e.g., PROLEC-SE: Ramos & Cuetos, 1999). Consequently, we designed a study with a group of seventh- and eighth-grade students (12–14 years old: henceforth the lower grade level group) and another group of ninth- and tenth-grade students (14–16 years old: henceforth the higher grade level group). Participants read two single texts and wrote a summary of each as an indicator of their comprehension and ability to select and organise the texts' important information using the structure strategy. In addition, the level of rhetorical competence of the participants (a core skill for expository reading comprehension) and two other skills that are relevant to the understanding of all kinds of written materials (decoding and general reading comprehension) were assessed.

Our first objective was to evaluate readers' ability to use the structure strategy. To do this, we manipulated the presence of signals that made the organisation of a sequential text ("Greece") and a cause-effect text ("Rice") explicit. Both texts introduced material that had not already been covered in class given that having previous knowledge of the subject could render the use of the structure strategy unnecessary (McNamara et al., 1996). Our hypothesis was that students at lower grade levels would be less competent in the use of the structure strategy and would better summarize (with more relevant and well-organised ideas) with signals than without them (i.e., they would experience the well-known signalling effect: Meyer et al., 2018). This was the case for the less competent students in the studies of McNamara et al. (1996) and Meyer et al. (1980), as well as the 11–13 years old participants in the study of Sánchez et al. (2017). In contrast, students at higher grade levels would deploy the structure strategy without signals (as did the more successful students in the studies of McNamara et al., 1996 and Meyer et al., 1980), at least in the text with a sequential structure (easier than the cause-effect structure: Williams et al., 2007).

Second, we wanted to evaluate at those same ages the impact on single-text comprehension of mentioning a source of authority and of source attention. The role of source for understanding text contents (beyond its role in validating/selecting and integrating information) has been stated by the literature (Brante & Strømsø, 2018; Rouet, 2006; Strømsø et al., 2010) but has not been systematically investigated, especially with single text. To do this, we manipulated in the texts the explicit mention of their authors (a professor from a prestigious university) and analysed (1) the impact of the manipulation on the selection and organisation of ideas in the summaries, (2) whether the students mentioned the sources when summarizing the texts (source attention), and (3) whether source attention (measured as the number of sources cited in the summaries) made a unique contribution to the selection and organisation of ideas in the summaries. There was one hypothesis for each of these specific objectives. First, source manipulation would influence the comprehension of students at least at higher grade levels because the type of information encapsulated

by the source could aid in anticipating the nature and features of a totally unknown text delivered by an equally unknown experimenter. Second, students at lower grade levels would not pay attention to sources—as secondary school students when reading multiple texts (Barzilai & Ka’adan, 2017; Britt & Aglinskias, 2002; Stahl et al., 1996; Wineburg, 1991)—while students at higher grade levels would pay attention because reading a single text is less demanding than reading a set of texts. Finally, we expected that students who paid attention to sources would write a better summary even when controlling other important reading skills (rhetorical competence, decoding, and general reading comprehension) because they could generate the expectation that an expository text organised in a logical way would be read instead of, for instance, an opinion extracted from a journal.

Our third objective was to explore the relationship between source attention and the structure strategy through rhetorical competence. Thus, a final hypothesis was that source attention (the number of sources mentioned in the summaries) would correlate with rhetorical competence—as both sources and signals can be considered metatextual cues (Hyland, 2010)—but that it would not (or to a lesser degree) correlate with decoding and general reading comprehension.

Method

Participants

A total of 284 seventh- to tenth-grade students (52% boys, 48% girls) from two state secondary schools in Salamanca (Spain) participated. Both schools were in peripheral urban settings where the average family income was in the 57th and 53rd percentiles with respect to Spanish income (Statistics National Institute; https://www.ine.es/experimental/atlas/experimental_atlas.htm).

Participants were divided into two groups according to the division of secondary education in Spain: students at lower grade levels (seventh and eighth grade, 12–14 years old: 136 students) and students at higher grade levels (ninth and tenth grade, 14–16 years old: 148 students). Fourteen participants were eliminated because they did not complete the tasks related to the dependent variable measures. All students were either native Spanish speakers or had a good level of Spanish, the language of all the materials used.

Texts and experimental reading conditions

The participants read a sequence (“Greece”) and a cause-effect (“Rice”) text (see Appendices 1 and 2). The text about Greece described three stages from the time of its domination by the Turks to its independence. Consequently, its top-level structure or the major schemata globally organizing its macropropositions (each stage) was sequential, although at a local level, in the description of those stages, there were some ideas related in a causal manner. The text on rice developed three causes that

explain why the supply of rice in Asia is at risk. According to the teachers of the participants, those topics had not yet been studied by their students.

Both texts were developed using unfamiliar texts from textbooks other than those used by the participants. They were modified to ensure that, even in the no-signal version, there were no coherence breaks and that each paragraph presented an important idea supported by examples. They were adjusted to be consistent in terms of word count (302), main ideas (4) and detailed ideas (16). The formal readability of both texts was high (Crawford Index 5.8 and 5.5: Crawford, 1984).

Four versions of each text were created by manipulating signals and sources: (1) text with signals and without source, (2) text with signals and source, (3) text without signals and with source, and (4) text without signals and without source. In the versions with signals, four specific organisational signals were added, indicating the general structure of the text (sequence or cause-effect: “The road to Greece’s independence was marked by three moments”, “There are three factors behind the concern for rice in Asia”) and introducing each of the three steps or causes (e.g., “At a later date”, “The main factor”, etc.). In the versions with a source, an explicit reference to the author of the ideas was included: a professor from a prestigious university (a credible source). Furthermore, to increase salience, the source information was embedded in the first paragraph of the texts (Bråten et al., 2016) and reiterated in the third paragraph in an abbreviated form.

Dependent variables

After reading each text, the participants wrote a summary. Two variables were obtained from each summary: the mention of the source and the quality of the summary. With respect to the former, we considered whether participants mentioned some feature (name, profession, expertise, or affiliation) of both sources, one or none. That is, we used a measure of attention to and memory for the source. In other studies, memory for sources has been measured using a test where participants have to match some sentences of the texts they have already read with each text the information came from (e.g., Strømsø et al., 2010). We have not followed this methodology because the test may be a cue for remembering the source information, and we were interested in assessing whether readers spontaneously paid enough attention to properly encode the source while reading and whether readers considered the source importantly enough to translate it into the summary. To assess the spontaneous source attention of the readers, we did not deliver any specific instruction related to the sources: we just asked readers to read with close attention because afterwards they would have to write a summary. Two judges, blinded regarding the experimental groups, independently analysed whether the source was mentioned in 40 randomly selected couples of summaries obtaining a Kappa of 1. Cronbach’s alpha for the number of sources mentioned was 0.78.

Concerning the quality of the summary, the number of main ideas was counted (4), and their organisation was scored as follows: 0 (there was no link between the ideas reported), 1 (the ideas were communicated with additive or descriptive links: in addition, furthermore...), 2 (there was some temporal link in the “Greece” summary or

some causal link in the “Rice” summary), and 3 (there was an overall link that anticipated the structure of the text and a causal/temporal link to introduce each main idea). Two judges, blinded regarding the experimental groups, independently analysed 40 randomly selected couples of summaries and obtained a Kappa of 0.90 (“Greece”) and 0.78 (“Rice”) in the enumeration of the main ideas and a Kappa of 1 in the organisational score for both texts. Cronbach’s alpha of the main ideas for the whole sample was 0.70 for both texts. For further analysis, a composite score was calculated by averaging the *z scores* of the main ideas and organisation (summary quality variable, henceforth).

Individual difference measures

Rhetorical competence

This task was an adaptation of one of the rhetorical competence scales employed by García et al. (2015) and García et al. (2019). It evaluates the processing of organisational signals. Participants read 17 passages, each containing three sentences: an introductory sentence, a sentence with a global organisational signal indicating the superstructure of the passage, and a sentence consistent with such superstructure. After reading each passage, the students had to choose the most appropriate continuation from three options. One point was awarded if the selection indicated that the participant had grasped the superstructure established by the organisational signals. Cronbach’s alpha for the whole sample was 0.70.

Decoding

Decoding was measured through a lexical decision task created by randomly combining the 40 words and 40 pseudowords of the Spanish PROLEC-SE battery (Ramos & Cuetos, 1999). Participants were given 2 min and 30 s to decide whether each item was a word or a pseudoword. The number of correct responses was counted. Cronbach’s alpha for the whole sample was 0.97.

General reading comprehension

The PROLEC-SE reading comprehension subtest (Ramos & Cuetos, 1999) was applied. Participants read two expository texts and answered 10 open-ended questions for each text (five literal and five inferential questions) without returning to the text. We counted the number of correct answers. Two judges, blinded regarding the experimental groups, independently analysed 40 randomly selected reading comprehension tasks and obtained a Kappa of 1. Cronbach’s alpha for the whole sample was 0.71.

Procedure

Consent for the study was obtained from the head teachers. All procedures performed in the study were in accordance with the local ethics policy at the time of the research, which did not require scrutiny by a specific ethics committee for studies of

this nature. The study was carried out in two group sessions of 50 min. In the first group session, participants completed the rhetorical competence task, the decoding task, and the general reading comprehension task. The tasks were presented on separate sheets of paper counterbalancing the order in the different classrooms. Two versions of the rhetorical competence task were provided to counterbalance the order of the items. All tasks were preceded by detailed instructions and examples.

In the second group session, participants read the two experimental texts and wrote the summaries with the passages out of view. The order of the two texts was randomly counterbalanced. The two texts were delivered in a booklet with the same version of both texts. Each participant was randomly assigned to one of the four versions (reading conditions).

Results

We removed three outliers in the individual variables considering the commonly used rule-of-thumb level of 3.0 standard deviation units from their means (Kline, 1998). Nine students did not complete the tasks of rhetorical competence and decoding, and thirteen students did not complete the general reading comprehension task. However, given the large sample size for each reading condition and age group (near or in excess of 30 participants), the assumption of normality was met (Darlington & Hayes, 2017).

The results are presented in five sections. In the first section, descriptive statistics are shown, and the equality of the participants in the individual variables is explored across the conditions. In the second section, the effect of the signals on the quality of the summary is examined to address our first objective. After that, we address the specific questions posed in our second objective. Thus, in the third section, we explore the effect of making the source of the texts explicit on summary quality; in the fourth section, we compare the number of sources mentioned among students at lower and higher grade levels; and finally, correlations and fixed-order hierarchical multiple regressions are performed to analyse the specific contribution of the number of sources mentioned to the summary quality. Such correlations, in turn, provide the data needed to also address our third objective: to study the relationship between source attention and structure strategy through rhetorical competence.

Descriptive statistics

Table 1 presents the means and standard deviations for all variables by age group and reading condition. A one-way ANOVA at each age group confirmed that there were no significant differences among the four reading conditions in the individual variables, neither among students at lower grade levels [$F_s(3, 122)$ between 0.09 and 0.51, $ps \geq 0.68$] nor among students at higher grade levels [$F_s(3, 128)$ between 0.30 and 0.58, $ps \geq 0.63$].

Participants' PROLEC-SE scores in general reading comprehension were very similar to those reported by the battery manual at these ages (Ramos & Cuetos,

Table 1 Scores for all variables by group of age and reading condition

Variables	Students at lower grade levels (seventh and eighth grade)				Students at higher grade levels (ninth and tenth grade)			
	Text with signals and source	Text without signals and with source	Text without signals nor source	Text with signals and no source	Text with signals and source	Text without signals and with source	Text without signals nor source	Text with signals and no source
Rhetorical competence	7.06 (2.54) N = 33	6.91 (2.41) N = 32	7.22 (3.20) N = 32	6.83 (2.79) N = 29	8.71 (3.71) N = 35	8.73 (3.67) N = 33	8.18 (3.47) N = 33	7.74 (3.27) N = 31
Decoding	63.12 (14.05) N = 33	63.09 (14.37) N = 32	62.00 (13.36) N = 32	60.07 (15.78) N = 29	69.69 (11.78) N = 35	69.36 (10.69) N = 33	70.09 (10.51) N = 33	67.35 (13.47) N = 31
General reading comprehension	10.22 (3.45) N = 32	9.23 (3.51) N = 30	9.22 (4.04) N = 32	9.43 (3.89) N = 28	11.43 (2.81) N = 35	11.76 (2.90) N = 33	11.97 (3.54) N = 33	11.29 (3.58) N = 31
“Greece”: summary quality (composite) ^a	0.25 (0.90) N = 33	0.31 (0.79) N = 34	-0.73 (0.32) N = 33	-0.57 (0.40) N = 32	0.73 (0.67) N = 36	0.84 (0.64) N = 34	-0.48 (0.43) N = 34	-0.49 (0.42) N = 31
“Rice”: summary quality (composite) ^a	0.32 (0.91) N = 33	0.35 (0.83) N = 34	-0.73 (0.41) N = 33	-0.67 (0.33) N = 32	0.79 (0.67) N = 36	1.02 (0.51) N = 34	-0.62 (0.38) N = 34	-0.65 (0.33) N = 31
Number of sources mentioned in both summaries	0.45 (0.75) N = 33		0.78 (0.85) N = 33		1.0 (0.92) N = 36		1.08 (0.93) N = 34	

^aComposite score by computing the average of the z scores from main ideas and organization

1999): mean = 9.55, $SD = 4.3$ in seventh and eighth grade; mean = 13.5, $SD = 3.32$ in ninth and tenth grade. Consequently, these data seem to be representative of Spanish students reading skills at these ages. In addition, students at higher grade levels outperformed students at lower grade levels in general reading comprehension, $F(1, 252) = 23.07$, $p < 0.01$, partial $\eta^2 = 0.08$, which justifies the division of the sample into these two groups for further analysis.

Signalling effect

Two 2×2 ANOVAs were conducted with two between-subjects factors: age group (students at lower vs. higher grade levels) and signals (with vs. without signals). The quality of the summary of “Greece” and “Rice” were the dependent variables.

In both analyses, the effect of age group was significant: $F(1, 263) = 19.90$, $p < 0.01$, partial $\eta^2 = 0.07$ in “Greece” and $F(1, 263) = 18.99$, $p < 0.01$, partial $\eta^2 = 0.07$ in “Rice”, meaning that students at higher grade levels outperformed students at lower grade levels. The ANOVAs also yielded a main effect of signals: $F(1, 263) = 222.62$, $p < 0.01$, partial $\eta^2 = 0.45$ in “Greece” and $F(1, 263) = 316.48$, $p < 0.01$, partial $\eta^2 = 0.55$ in “Rice”. This means that students performed better with signals than without them. The interaction between age group and signals was also significant: $F(1, 263) = 4.79$, $p = 0.030$, partial $\eta^2 = 0.02$ in “Greece” and $F(1, 263) = 12.28$, $p < 0.01$, partial $\eta^2 = 0.05$. This means that students at higher grade levels took more advantage of signals ($p < 0.01$, Cohen’s $d = 2.32$ in “Greece” and 3.09 in “Rice”) than students at lower grade levels ($p < 0.01$, Cohen’s $d = 1.43$ in “Greece” and 1.55 in “Rice”).

Source effect

We explored the impact of making the source explicit in the texts conducting two 2×2 ANOVAs with two between-subjects factors: age group (students at lower vs. higher grade levels) and source (with source vs. without). The quality of the summary of “Greece” and “Rice” were the dependent variables.

In both analyses, only the age group effect was significant: $F(1, 263) = 11.87$, $p < 0.01$, partial $\eta^2 = 0.04$ in “Greece” and $F(1, 263) = 9.71$, $p < 0.01$, partial $\eta^2 = 0.04$ in “Rice”. Neither the source nor the interaction had a significant impact on the quality of the summary, regardless of the text, $F_s(1, 263) \leq 0.88$, $p_s \geq 0.35$.

Source attention

The number of students (only those from reading conditions with a source) who referred to zero, one or two of the sources in the summaries, is shown in Table 2. Students at higher grade levels cited more sources than students at lower grade levels, $\chi^2 = 8.28$, $p = 0.016$.

Table 2 Number and percentage of students who mentioned zero, one or two sources in their summaries by group of age

Group of age	How many sources did they mention?		
	Zero	One	Two
Students at lower grade levels	39 (59.1%)	13 (19.7%)	14 (21.2%)
Students at higher grade levels	28 (40%)	11 (15.7%)	31 (44.3%)

Table 3 Correlations between variables. Above diagonal, text with signals and source; below diagonal, text without signals and with source. All correlation tests use Pearson's with the exception of correlations involving number of sources mentioned, which use Kendall's tau because of this variable being a count of occurrences

	1	2	3	4	5	6
1. Number of sources mentioned		0.26**	0.05	0.10	0.28**	0.26**
2. Rhetorical competence	-0.00		0.08	0.28**	0.22**	0.24**
3. Decoding	0.04	-0.12		0.22*	0.32**	0.32**
4. General reading comprehension	-0.03	0.18*	0.18*		0.18*	0.35**
5. "Greece": summary quality (composite)	-0.01	0.07	0.22*	0.25**		0.57**
6. "Rice": summary quality (composite)	-0.02	0.07	0.12	0.29**	0.16	

** $p < 0.01$, * $p < 0.05$

Relationship between source attention and the rest of the variables and contribution of source attention to summary quality

Correlations between all variables in the groups who read the texts with sources are presented in Table 3. We differentiate the correlations among the group who read the texts with signals from the correlations among the group who read the texts without signals due to the impact of signals on summary quality. Among participants who read the texts with signals, the number of sources cited was positively correlated with the summary quality of both texts and with rhetorical competence but was not correlated with either decoding or general reading comprehension. However, among participants who read the texts without signals, the number of sources cited was not correlated with any other variable. To further explore these results, we used the PROCESS macro developed by Hayes (2018) for SPSS to confirm that the relationship between rhetorical competence and the number of sources cited was moderated by the presence of signals in the texts ($B = 0.093$, $p = 0.045$); we also assessed a possible interaction between signals and number of sources cited for summary quality in the following regressions.

Fixed-order, hierarchical multiple regressions were conducted to determine whether the number of sources mentioned accounted for unique variance in summary quality above and beyond the influence of individual variables (see Table 4). According to the analysis of correlations, we conducted three sets of regressions on (1) the groups who read the texts with signals and sources, (2) the groups who read

the texts without signals and with sources, and (3) all groups who read the texts with sources to test the interaction between signals and the number of sources mentioned (in these regressions, we introduced an interaction term between signals and the number of sources mentioned, and we introduced signals as a dummy variable with the text without signals coded as 0 and the text with signals coded as 1). In the first step, we introduced individual variables as controls (rhetorical competence, decoding, and general reading comprehension) plus, in the third set of regressions, signals and number of sources mentioned. In the second step, we introduced the number of sources cited or, in the third set of regressions, the interaction term between signals and the number of sources. The average z score of the summary quality of both texts was the outcome variable. For these regressions, tolerance values were above 0.35, and all variance-inflation factors (VIFs) were well below 10. Control variables (in Step 1) accounted for significant variance in all regressions. The number of sources mentioned accounted for significant additional variance when introduced in Step 2 in the group of readers who read the texts with signals, but it did not in the group of readers who read the texts without signals. The interaction term between signals and the number of sources mentioned accounted for significant additional variance when introduced in Step 2 in all groups who read the texts with sources. Jointly, these results indicate that (1) the contribution of the variable number of sources mentioned was significantly different when the texts were signalled and when the texts were not signalled, and (2) the number of sources mentioned accounted for unique variance in summary quality above and beyond the influence of individual variables only when the texts included organisational signals.

Discussion

There were three main aims of this study: (1) to examine whether participants were able to spontaneously use the structure strategy, (2) to assess the impact of source manipulation and source attention on reading comprehension, and (3) to analyse whether there was a relationship between source attention and the structure strategy through rhetorical competence (the ability needed to take advantage of written signals). The results are discussed in the context of these aims.

Use of the structure strategy

To assess students' ability to use the structure strategy, according to the signalling effect paradigm (Meyer et al., 2018), participants read texts with or without signals specifying their organisation (organisational signals). Our hypothesis was that students at lower grade levels would write better summaries when reading texts containing signals (signalling effect), but students at higher grade levels would do equally well with and without signals (no signalling effect), at least in the sequential text. The results, however, revealed that both groups of students performed better with the help of signals and that this effect was *large* for both texts. In addition, a posteriori analysis showed that only one student in each age group obtained the

Table 4 Summary of fixed-order hierarchical regression analyses on summary quality of the two texts with source

	Summary Quality (average of "Greece" and "Rice" with signals and source)			
	R^2	ΔR^2	F	Final standardised beta weights
Step 1. Rhetorical competence, decoding, and general reading comprehension	0.35	0.351	11.338**	–
Step 2. Number of sources mentioned	0.40	0.051	5.234*	0.24
	Summary Quality (average of "Greece" and "Rice" without signals and with source)			
	R^2	ΔR^2	F	Final standardised beta weights
Step 1. Rhetorical competence, decoding, and general reading comprehension	0.16	0.161	3.899*	–
Step 2. Number of sources mentioned	0.16	0.003	0.185	0.05
	Summary Quality (average of "Greece" and "Rice" with source)			
	R^2	ΔR^2	F	Final standardised beta weights
Step 1. Rhetorical competence, decoding, general reading comprehension, signals, and number of sources mentioned	0.66	0.660	48.989**	–
Step 2. Signals x number of sources mentioned	0.67	0.013	4.961*	0.19

** $p < 0.01$, * $p < 0.05$

maximum score for the organisation of the summary when reading the texts without signals, while a considerable percentage of students achieved this score with the aid of signals (between 41.8 and 71.4%, depending on the age group and text). This reveals that even older students better deployed the structure strategy with signals. Such a result is not surprising in the “Rice” text, as the cause-effect structure is quite complex (Williams et al., 2007), but it is remarkable that the students at higher grade levels did not perform better without signals in the sequential text (“Greece”). Perhaps the presence of Greek names made reading difficult (see Appendix 1).

The above results suggest that even students at higher grade levels of secondary education, regardless of the structure of the text (cause-effect, sequential, etc.), may find it difficult to follow its organisation with content that is too far from their knowledge or experience if the text does not include signals. In fact, prior knowledge moderates the effect of signals (McNamara et al., 1996): signals are useful when one does not already have knowledge in the field of the text. In this study, we presented texts dealing with unfamiliar content to avoid the risk that, if the text speaks of something familiar, instead of using the structure strategy, readers simply impose an organisation that is already stored in their long-term memory. However, this approach makes it impossible for us to know whether the signalling effect found in both age groups is the result of the lack of development of the structure strategy or whether a prior knowledge base is also required to implement this strategy even without the presence of signals. Moreover, because we did not assess prior knowledge, we cannot exclude differential exposure to the topics among the participants. Further studies are needed to reveal the interactions between the structure strategy and different amounts of prior knowledge.

Impact of sources and source attention on reading comprehension

Our second objective was to assess the impact of source manipulation and source attention on reading comprehension. Regarding source manipulation, our hypothesis was that at least the students at higher grade levels would better understand the texts with an explicit authoritative source. Nevertheless, source manipulation had no significant effect on summary quality in either of the two texts or in either of the two age groups. This means that students did not use the source as a way of obtaining information about the kind of text that they were going to read or that information was not useful enough to facilitate text understanding. Nevertheless, before elaborating a conclusion about the role of sources in the present study, we need to assess the other two hypotheses related to the second objective.

Regarding source attention, we expected students at higher grade levels to be more source-sensitive than students at lower grade levels. The results confirm this hypothesis: although a good percentage of the students at lower grade levels mentioned one or both sources in their summaries (41%), this percentage was larger among students at higher grade levels (60%). In addition, an a posteriori analysis showed that citing the source is not simply a consequence of remembering more details of the texts because the correlation between the number of sources mentioned and the number of detailed ideas was not significant in either summary

($r_s=0.08$ and -0.01 , $p_s=0.23$ and 0.87). It seems therefore that citing the source in the summaries responds to selective behaviour. Thus, the participants from this study showed more source attention than students from prior research at similar ages reading multiple texts (Barzilai & Ka'adan, 2017; Britt & Aglinskas, 2002; Stahl et al., 1996; Wineburg, 1991). These results seem striking because source sensitivity is often greatest in tasks with conflicting ideas (Braasch & Bråten, 2017). Nevertheless, it could be explained by at least four factors. First, remembering the source of a single text could be quite manageable for secondary education students. Second, we used texts from the Spanish subject “Geography and History”, and reflecting on the sources of the documents is in line with the curriculum of this subject (Orden Edu 362, 2015). Third, both sources were mentioned twice and were particularly prominent and easy to remember (our hypothetical professors were from the well-known universities of Oxford and Cambridge). Fourth, we considered that the source had been mentioned if a student included in the summary any feature of the source (name, profession, expertise, or affiliation). This was a very broad criterion, but because participants only read single texts with only one embedded source, they did not need to generate a very precise representation of the source.

Finally, the third hypothesis of our second objective was partially confirmed. The number of sources transferred to the summaries by each participant made a unique contribution to the quality of the students' summaries (beyond rhetorical competence, decoding, and general reading comprehension) but only considered the average score of the summary quality of the texts with signals. Thus, students who were more sensitive to the source of the texts with signals did select and organise their ideas better than those who were not, perhaps because the source (a university professor) nudges those readers to follow the organisational signals and use of the structure strategy.¹ That is, when readers find an organisational signal, they have to detect it, interpret it, and transform its suggestion—e.g., “look for causes”—into a personal reading objective—e.g., “I am going to find the first cause” (Sánchez et al., 2020). Because this last process implied a compromise, it may be fostered when a reader detects that the instruction contained in the organisational signals is delivered by an expert. Of course, this interpretation needs more evidence, but these data indicate that the relationship between sourcing skills and reading comprehension found in multiple documents (Bråten et al., 2009; Britt & Aglinskas, 2002; Goldman et al., 2012; Strømsø et al., 2010; Wiley et al., 2009) may also be present in single texts, as some authors have argued (Brante & Strømsø, 2018; Rouet, 2006; Strømsø et al., 2010), but perhaps only if those texts have some features, such as the complexity of the content or the presence of organisation signals that help them to select and organise the ideas they read.

Taken together, the results related to our second objective suggest that including an authority source in single texts does not have a direct impact on reading

¹ Nevertheless, we cannot discard that, if this relationship has been found only in the texts with organisational signals may be because the texts without signals were very difficult of understanding: on average, the whole sample translated to the summaries only the 23% of the main ideas of “Greece” and the 19% of the main ideas of “Rice” when the texts were read without signals.

comprehension: it depends on the reader's attention to them and the type of text. When the text contains some aids to foster comprehension (e.g., organisational signals), it is possible that the source reinforces the function of those aids for readers that pay attention to them.

Regarding the relationship between source attention and the structure strategy through rhetorical competence

Finally, our third objective was to explore the relationship between the structure strategy and source attention through rhetorical competence: a skill that allows taking advantage of signals such as those that serve as guides for using the structure strategy (Sánchez & García, 2009; Sánchez et al., 2017, 2020). Our hypothesis was that rhetorical competence and source attention would be linked because rhetorical signals and sources may be considered metatextual cues that clarify some aspects of the text (Hyland, 2010). Indeed, we found that the number of sources mentioned in the summaries was positively and exclusively correlated with rhetorical competence (not with decoding or general reading comprehension), although only among the students who read the texts with signals. The explanation could be that the processing of the organisational signals competes with the processing of sources, and only students with a certain level of rhetorical competence were able to process organisational signals and keep some cognitive resources available to pay attention to the sources. In the texts without signals, there is no such competition, and participants can pay attention to sources regardless of their level of rhetorical competence. We obtained confirmation of this explanation through an additional moderation analysis with PROCESS (Hayes, 2018). This analysis yielded that rhetorical competence moderated the difference in the number of sources mentioned after reading the texts with organisational signals or without them ($B=0.093$, $p=0.045$). More specifically, the Johnson-Neyman technique showed that the number of sources mentioned in the summaries was significantly lower after reading the texts with signals than the texts without signals among students with a level of rhetorical competence under 6.68 (39% success in the rhetorical competence tasks).

In sum, we found a relationship between rhetorical competence and the number of sources mentioned in the summaries, but this relationship was slightly different than we expected. In texts with organisational signals, the processing of these signals seems to be a priority, and, consequently, rhetorical competence arises as a prerequisite for paying attention to the sources.

Conclusions

Students in secondary education still need written signals to better launch the structure strategy with some texts. At the same time, they are improving their sensitivity to sources, and this sensitivity may be useful to understand texts with signals. However, the inclusion of written signals or rhetorical devices may hinder source attention because they demand the same cognitive resources. In this scenario, rhetorical

competence becomes a crucial skill for efficiently processing rhetorical devices without hindering source attention.

In more general terms, Spanish secondary education seems to be a critical moment for literacy because the development of some single-text reading skills (e.g., the structure strategy) coexists with the development of other more sophisticated competencies usually attributed to disciplinary literacies and multiple-text tasks (e.g., sourcing). That is, the development of reading competence does not follow a sequence of staggered challenges; rather, those challenges are cooccurring events (Alexander & Disciplined Reading and Learning Research Laboratory, 2012). We knew that these challenges and competencies were related (Florit et al., 2020; Mahlow et al., 2020; Salmerón & García, 2011); this study has found new relationships between them and has shown that reaching a certain level in some skills may be a prerequisite for the domain of others.

Limitations

The main limitation of this study is that we did not register measures of online processing (e.g., thinking-aloud protocols), and we did not conduct postreading interviews to better understand how readers processed organisational signals and source information. It is possible that some readers processed organisational signals and were able to use the structure strategy, but they did not translate the main ideas to the summaries in an organised way for other reasons (because, for instance, they interpreted the task as a request to explain just the topic of the text). In a similar way, we cannot be sure of the reasons for including or not source information in the summaries: some students, for instance, may process source information and, nevertheless, they may think that a summary does not need to include it.

Another limitation is that, as we were only able to assess source attention among readers of the reading conditions with source, our design does not allow us to analyse whether source attention moderates the effect of source mention in the texts: to answer this question, we would have had to take a source attention measure independent of the summary of the experimental texts.

Finally, we used summary quality and the number of sources mentioned in the summaries as indicators of the use of the structure strategy and source attention, but we are aware that these indicators may also reflect additional processes (e.g., written ability, memory).

Implications

This study has some instructional implications. First, it seems that the structure strategy warrants being taught to secondary education students, as proposed by several studies (see the meta-analysis by Hebert et al., 2016; Pyle et al., 2017), although it may not be necessary to explicitly teach the type of signals that usually accompany each textual structure because our participants were very sensitive to them. Second, secondary education students can benefit from the presence of written signals that make the connections between ideas in texts more explicit, but in their absence,

other ways of showing textual organisation, such as oral requests, could also be useful (Sánchez et al., 2020). Continuing to provide them with this support would therefore be advisable. Finally, even when working with single texts, it would seem advantageous to systematically incorporate an explicit and complete representation of the documentary sources (Britt & Rouet, 2012), but it is important to consider that the processing of the sources may be easier after facilitating the comprehension of the texts and the organisation of their ideas.

Appendix 1

Greece

(Version with organisational signals and source in italics).

The road to Greek independence *was marked by three moments. James McCartney, professor of history at the University of Cambridge and a member of Trinity College explains it as follows.*

First, the entry of the Turks into the Acropolis in May 1827 was pivotal in the Turkish domination of mainland Greece. The situation was also dire in other areas. For example, in the Peloponnese, there was no resistance to the invaders. Similarly, towns such as Iteia, Messinia and Tripolitsa were completely destroyed.

At a later date, explains the Cambridge University professor, in October of the same year, after the naval battle of Navarino, the Greeks realised that their independence would not be long in coming. That year they began a series of military actions and the fight against the Turkish invader intensified. Led by Dimitrios Ypsilantis and Kitsos Tzavelas, many Greek villages and towns were liberated. The victories of the Greek army on one side and the diplomatic efforts of the Greek politicians on the other, accelerated the whole process. Thus, the negotiations held by Kapodistrias with England and France, for instance, were instrumental in achieving independence. Kapodistrias had to convince the English and French to support Greek independence in the face of growing influence from Russia.

Finally, in February 1830 in London the three allied forces (England, France, and Russia) signed an agreement for the political independence of Greece. The borders were established on the line of the Axeloos-Sperxios River. Two years later, the borders of the Greek state were extended to the Ambrakikos-Pagasitikos bay. The new borders were recognized by the Turks themselves. After ten years of conflict, the existence of the independent Greek state was now a fact.

Appendix 2

Rice

(Version with organisational signals and source in italics).

There are *three factors behind the concern for rice in Asia*. Peter Harrison, Professor of Economics at Oxford University and a Fellow of Magdalen College, explains it as follows.

The main factor is that the Asian population, now at the beginning of the twenty-first century, is increasing by some 56 million persons each year. Rice is a vital resource of Asia. Ninety percent of the world's rice production is consumed. Demand will reach 770 million tonnes by 2025.

A second cause for concern, explains the Oxford University professor, is that after the "Green Revolution", as it was called, between 1960 and 1980, technology advanced to the point at which harvests almost exhausted their productive possibilities. Annual increases in rice production have declined by about 1.25 percent since 1990. Production is declining the most in precisely those areas that are most suitable for cultivation. The decline in production, on the one hand, and the reduction in the area of rice fields, on the other, have set off alarm bells. In China, rice fields were reduced from 37 million hectares in 1976 to 31 million hectares in 1996. Degradation of rice-intensive land is likely to further reduce the irrigated area in Asia.

Finally, the population working in rice fields throughout Asia is increasingly aging. The average age of farmers is increasing globally. In Korea, the number of rice farmers decreased by two-thirds between 1965 and 1995. Urbanization and industrialization will further reduce the agricultural population. Mechanization and modernization of agriculture are increasingly essential.

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